FS Air Program Critical Loads Implementation Strategy (March 2008)

STEP 1: Determine whether any Critical Loads work has already been done in your area.

Summary of Critical Loads in the United States produced by Linda Pardo, provides a list of publications with Critical Loads Data. (Please note that this summary does not provide a rating of the CL calculations, and see the discussion on uncertainties under Step 3.)
http://nrs.fs.fed.us/tools/cl/web_site_documents/CL_of_Acidity_Literature_Database_tables.pdf

A literature review will assist you in defining your concern in Step 2. For example, if you are unsure of the issues associated with deposition in your area, a literature review can help you identify them.

Yes:
Use the Results if the CL is relevant to your site & the level of uncertainty associated with the CL calculation is acceptable to you for your intended use. (See discussion on uncertainty under Step 3 of this strategy).

No

STEP 2: Define Your Concern:

The following questions will give a quick synopsis of each topic to help you identify whether it may be an issue in your area(s).

Acidity

- Is there elevated deposition of Sulfur or Nitrogen in the area?
- Does the lithology/geology of the area have a low buffering capacity for acidity?
- Does the area have shallow soils?
- Does the area have very old weathered soils?
- Is the area you are concerned about high elevation?
- Do you have water chemistry data that indicates low buffering capacity (i.e. ANC, pH values)

Nutrient N

- Is there elevated deposition of Nitrogen in the system?
- Did the area historically have low Nitrogen deposition?
- Have there been observed shifts in species composition of sensitive species in the area?
- Are there elevated stream water nitrate concentrations?

Both

Define Risk/Risk Assessment - Acidity

If the answer to many of the previous questions is yes, it may indicate a potential for negative effects from acidic deposition. However, due to funding or other limitations, you may need to narrow your scope to just a few areas for which you would calculate a critical load (i.e. a subwatershed level vs. a forest level). The risk assessment step can be used to identify the most sensitive areas and narrow your scope if you are unsure of where you have issues related to acidification.

Define Risk for Nutrient N

Again, if the answer to many of the previous questions is yes, it may indicate a potential for negative effects from N deposition. The following box list several methods for helping you identify whether this is the case.

Define Risk/Risk Assessment for Acidity Continued

a.) **What is the estimated total (dry + wet + occult) deposition rate for S and N?** For comparison, check the NRIS Air AQRV database or the National Air Program Website (http://www.fs.fed.us/air/) for "Pollutant Exposures of Concern" for sulfur and nitrogen listed for wildernesses with similar physical and biological characteristics near the area of interest. Do the estimated total sulfur and or nitrogen estimates exceed the "Pollutant Exposures of Concern" for any wilderness with similar characteristics near the area you are evaluating? These "concern thresholds" come from the national or regional screening procedures documents on the website.

b.) Rank 6th level hydrologic unit codes (HUC) or area(s) of interest to identify which HUC or areas have the greatest potential to be impacted by deposition. (*Rank watersheds based on the sensitivity of the lithology, elevation and forest cover type*). This will allow you to identify areas you should be most concerned about in terms of impacts verses those you can rule out.

c.) Do you have any existing data for chemical indicators (i.e. ANC values for aquatic resources)? Do any of these data have values which exceed a "concern threshold" for a chemical indicator? If not, gather data for the chemical indicators (i.e. ANC values) from the HUC(s) or area(s) identified as having the greatest potential of risk for adverse impacts from nitrogen and/or sulfur deposition. The point of this step is twofold; first, if the site data for sensitive receptor indicators can be corroborated with the 6^{th} level HUC rankings determined in the previous step, this can give weight of evidence to your ranking criteria. The second point is that if they exceed a "concern threshold" for a similar area, it indicates potential impacts to one or more Air Quality Related Values.

Define Risk for Nutrient N Continued

a.) **What is the estimated or measured total (dry + wet + occult) deposition rate for reactive N?** For comparison, check the NRIS Air AQRV database or the National Air Program Website for "Pollutant Exposures of Concern" for nitrogen listed for wildernesses with similar physical and biological characteristics near the area of interest. Do the estimated nitrogen estimates exceed the "Pollutant Exposures of Concern" for any wilderness with similar characteristics near the area you are evaluating?

b.) Additionally, compare current levels of N deposition at your site to an empirical critical load for a similar site in "Empirical Critical Loads for nutrient N" (Table 5.1 in the ICP Mapping Manual section 5.2.1.3.) This document is available at the following website: http://www.icpmapping.org/ If deposition in your area of concern exceeds or is near these values, then it may be an indication that effects are occurring and there is need for a more site specific critical load.

c.) Are specific sensitive receptors currently receiving elevated inputs of reactive N? (i.e. high elevation lakes).

If the results from the risk assessment(s) indicate that you have areas that may be negatively impacted by acidic deposition or nutrient enrichment, you would want to move on to Step 3: Calculate a Critical Load.

STEP 3: Determine Methodology for Critical Load Calculations for Acidity or Nutrient N or Both

Before You Begin:

There are several things to think about before you move forward with any Critical Load calculation.

Calculation Methods:

First, be aware that there are multiple methods for collecting data needed to calculate critical loads. Additionally, the methods and the results will vary for different sensitive receptors (i.e. diatoms vs. fish) and even for different indicators (often chemical) for the same sensitive receptor. Each method requires varying levels of data intensity. An overview of the various approaches that can be used and the respective data intensities required can be found in: ***Approaches for Estimating Critical Loads of N and S Deposition for Forest Ecosystems on U.S. Federal Lands*** (Pardo) .http://www.fs.fed.us/ne/durham/4352/critical_loads/Critical_loads_webs/products.htm

Levels of Uncertainty:

Second, each critical load calculation has some degree of uncertainty associated with that calculation, which comes from two main sources. First, there is uncertainty that is more or less random and caused by existing environmental variability (i.e. the high degree of variability in soils). The second type of uncertainty is associated with varying methods for data collection (i.e. use of site specific data that is representative of the entire site vs. extrapolated or modeled data, or the use of a broad scale critical load calculation vs. a more site specific finer resolution calculation). This second source of uncertainty can be minimized or reduced by intensifying the level of site specific data, which would involve some determination of how representative the data is of the whole site.

Intended use:

How you intend use a calculated critical load value will to some degree drive the level of uncertainty in the calculation that you are willing to live with, the sensitive receptor(s) and indicator(s) you choose to calculate the critical load for, and ultimately the methodology you feel is appropriate to meet this intended use. For example, you may be willing to accept a higher level of systematic uncertainty in a critical load value if you intend to use it to qualitatively discuss current conditions of a class II wilderness. You may not be willing to accept this same level of uncertainty when making AQRV impact determinations for a Class I area for PSD permit. Additionally, the level of available data will drive which method you can use.

Methodologies for both Acidity and Nutrient Nitrogen – Resources

Resources - Overview of Methodologies:

ICP Mapping Manuals:

- The critical loads concept has been implemented in Europe for some time now. Much work has been done on calculating and mapping critical loads across Western Europe. Extensive information on the European program methodologies for modeling and mapping critical loads can be found in the ICP Mapping and Modeling Manual, available online at: http://www.icpmapping.org/. This website has information on modeling and mapping critical loads for Acidity, Nutrient N and heavy metals.

Linda Pardo Documents: http://www.fs.fed.us/ne/durham/4352/critical_loads/Critical_loads_webs/products.htm

- For an overview of the various approaches that can be used and the respective data intensities required see ***Approaches for Estimating Critical Loads of N and S Deposition for Forest Ecosystems on U.S. Federal Lands*** (Pardo)

- A second document, ***Protocol for calculating critical loads of Nitrogen and Sulfur deposition for forest ecosystems in Forest Service class I areas*** (Pardo et al.), outlines procedures and a general approach scheme for how FS personal should go about calculating a critical load. The document outlines an *Order of Preference* for methods that should be used based on data availability for a given site. An appendix to this document provides recommendations for critical load calculation methods for each Forest Service Class I area, based on known data availability. This *Order of Preference* is as follows:

Methodologies – Resources Continued

1.) *Intensive Data – use dynamic modeling* - If sufficient data and funding are available, a dynamic model such as NuCM, MAGIC, SAFE, SMART, PnET-BGC and DayCent-Chem can be used to calculate time to recovery or time to damage. These models do require considerable data which include one or more of the following: soil chemistry, soil water chemistry, water chemistry, forest cover and /or nutrients, mineral weathering rates, meteorological data, and/or historical and possibly future atmospheric deposition data. You should plan on hiring a contractor who has clearly demonstrated expertise in the use of the model(s) selected to perform the analysis.

With the data intensity required, use this step only if inventory/monitoring data and other analysis completed indicate area(s) of interest are suffering from acidic deposition and you want to accomplish one or more of the following:

- You want to understand how one or more sensitive receptor indicators may change in the future.
- You want to develop somewhat refined critical loads for nitrogen and/or sulfur deposition.
- You are considering mitigation methods to restore the watershed health.

2.) *Moderate Data (Pardo et al.)* – If a moderate level of data is available; the SSMB or the VSD models can be utilized using a combination of site data and empirically derived categories for areas where data is lacking.

3.) *Few Data- Use the Empirical (Pardo et al.)* – If data is lacking, a site can be categorized according to its characteristics and then empirical approaches can be applied based on the site categorization. Various approaches for estimating parameters needed in critical loads calculations when using the categorical approach are listed under the **Empirical critical loads for acidity** section.

Methodologies/Resources Specific to Acidity

Estimates of critical acid loads and exceedances for forest soils across the conterminous United States, McNulty et al: *(*doi:10.1016/j.envpol.2007.05.025 *)*

- Large scale Critical Loads Mapping (1 km resolution) for the lower 48 states.
- Designed for terrestrial systems (based on vegetation effects) but can have broader implications for aquatic systems in the watershed.
- Used soils data (STATSGO), deposition data – wet (NADP, Grimm & Lynch) and estimates of dry and cloud deposition, and vegetation data in a simple mass balance equation to develop critical loads.

Uncertainty analysis on simple mass balance model to calculate critical loads for soil acidity, Harbin and McNulty: (doi:10.1016/j.envpol.2007.05.014)

Methodologies/Resources Specific to Nutrient N

Estimating Susceptibility to N Saturation
N saturation can be calculated using mass balance approaches, similar to those for acidity, only the inputs are deposition of N and N fixation, and the losses are N leaching, N in biomass removed, N accumulation in soil and gaseous losses of N, as described in ***Approaches for estimating Critical Loads of N and S Deposition for Forest Ecosystems*** (Pardo) referenced above.

Additional information on establishing acceptable levels of Nutrient nitrogen can be found in EPA's "Nutrient Criteria Technical Guidance Manual" (EPA, 2000):
http://cacaponinstitute.org/PDF/EPA%20tech%20guidance%20Nutrients%20for%20lakes.pdf

** Also see the ICP Mapping and Modeling Manual section 5.2.1.3 as described above.

STEP 4: Gather Data & Calculate Critical Load

Data Management

Several documents are available on the Pardo website to assist with data management concerns associated with the Forest Service Critical Loads Protocol. These include the ***Data Management Protocol*** (appendix C to the Protocol Document) and ***Instructions to accompany the data requirement check list for calculating critical loads for N and S for forest ecosystems***. These can be downloaded under the Data Management section of the following website: http://www.fs.fed.us/ne/durham/4352/critical_loads/Critical_loads_webs/products.htm This document lists the types of data that are either required or optional for Steady State Mass Balance Calculations and distinguishes between direct model inputs, calculated model parameters, background data and additional analyses for interpreting model outputs. Additionally, this document provides information on assembling the data, including a ranking of various data sources.